

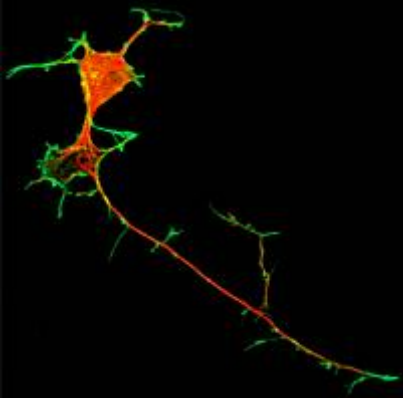
Space Exploration: Challenges in Medicine, Research, and Ethics

Jeffrey R. Davis, M.D.
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NASA Johnson Space Center

27 April 2007

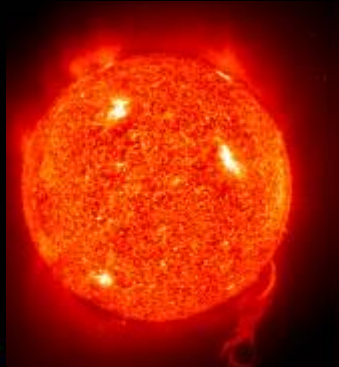


Effects of Microgravity on Human Physiology



Behavior & performance

Neurovestibular



Radiation

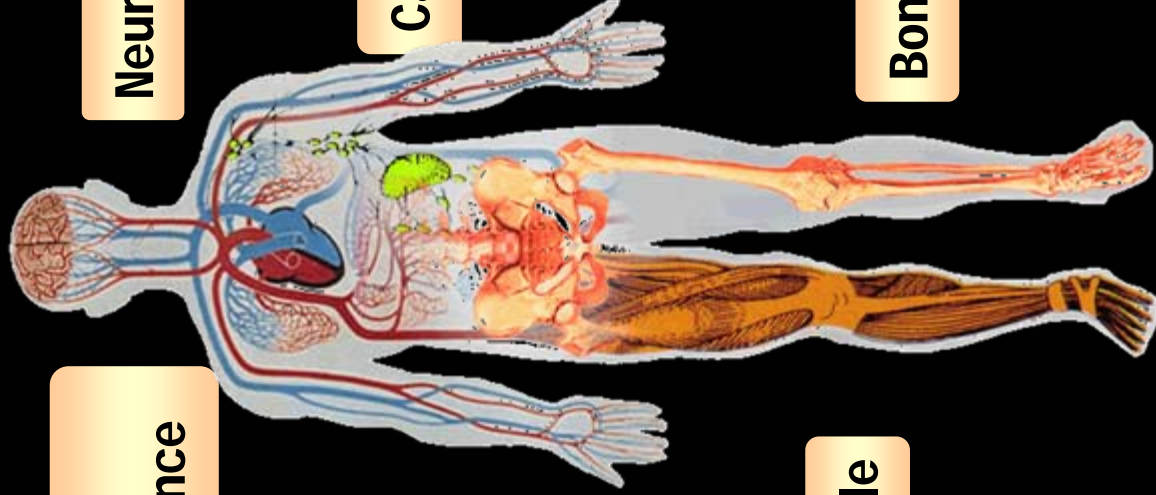
Cardiovascular



Muscle



Bone

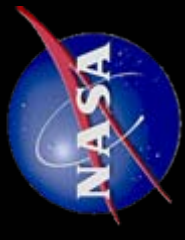
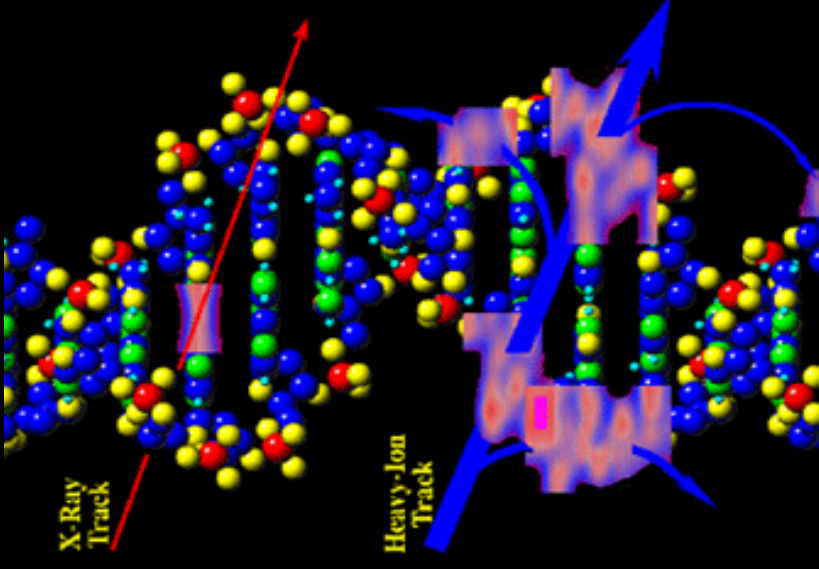


Space Studies and Results



Radiation

- Causes
 - Galactic cosmic rays
 - Protons and electrons trapped in Earth's magnetic field
 - Solar particle events
- Consequences
 - Cataracts
 - Cancer
 - Central nervous system damage
 - Acute radiation sickness

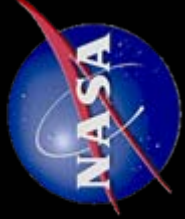




Radiation

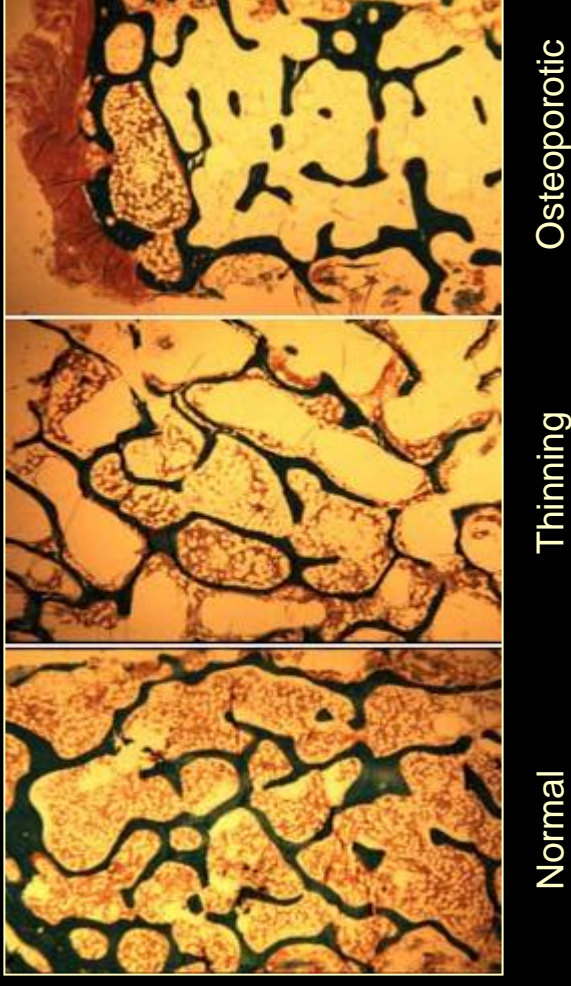
Countermeasures

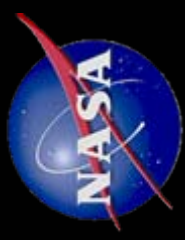
- Shielding
- Pharmacotherapeutics



Bone

- Causes of bone loss
 - Interplay among biomechanical factors, hormonal and metabolic balance
 - Skeletal unloading
- Consequences
 - Increases clinical risk of
 - Stress/traumatic fractures
 - Impaired fracture healing
 - Soft tissue injury
 - Renal stone formation





Bone

- Countermeasures
 - Exercise
 - Nutrition
 - Artificial gravity
 - Pharmaceuticals
 - Midodrine for postflight orthostatic hypotension
 - Alendronate for bone loss



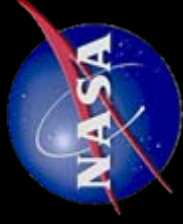


Behavior and Performance

- Causes of changes
 - Sleep loss, circadian desynchronization
 - Fatigue and work overload
 - Planned and unplanned events
 - Spacecraft environment
- Consequences
 - Stress-induced anxiety
 - Crew or crew/ground control conflict
 - Psychosomatic complaints



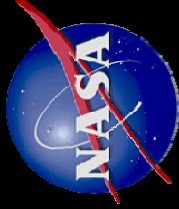
Behavior & Performance



Sunset over North America 2-1-03

Countermeasures

- Schedule changes to minimize crew fatigue and reestablish circadian rhythms
- Family contacts
- Private medical conferences
- LED blue light treatment



Muscle

- Causes of loss
 - Muscle protein synthesis
 - Lack of muscle loading
- Consequences
 - Loss of strength, power, and endurance
 - Increased excretion of muscle breakdown metabolites (nitrogen, potassium, creatine, amino acids)





Muscle

- Countermeasures
 - Medications
 - Aerobic and resistive exercise regimens



Jeffrey R. Davis, MD



Cardiovascular

- Causes
 - Fluid pools in upper body
 - Blood volume and heart volume decrease
- Consequences
 - Aerobic capacity decreased
 - Heart rate decreased
 - Cardiac output increased



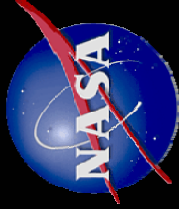
Cardiovascular



Countermeasures

- Exercise
- Pharmacology
- Treatment
 - CPR
 - Defibrillator





Neurovestibular

- Causes
 - Altered sensory stimulus
 - Rearrangement of signals, from eyes, muscle, vestibular receptors
- Consequences
 - Disorientation
 - “Motion” sickness
 - Perceptual illusions
 - Disturbances of
 - Eye-hand coordination
 - Balance control
 - Gait





Neurovestibular

- Countermeasures
 - Training
 - Pharmacological
 - Spatial re-orientation

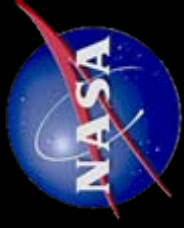




Food and Nutrition

- Causes
 - Altered senses
 - Decreased appetite
 - Stress
- Consequences
 - Decreased fluid intake
 - Decreased energy intake
 - Preference for carbohydrates versus fat
 - Body composition changes
 - Fluid and electrolyte homeostasis



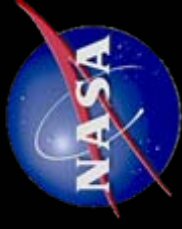


Food and Nutrition

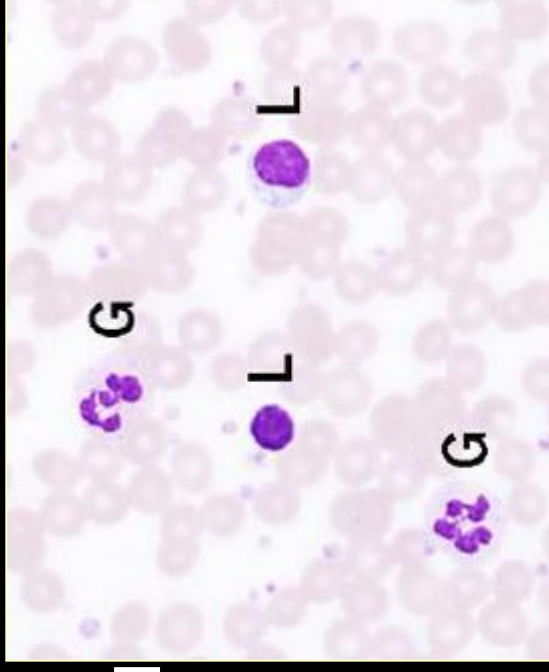
- Countermeasures
 - Satisfy metabolic requirements
 - Water balance
 - Ample pantry for crew preferences
 - Additional food
 - Increased shelf-life



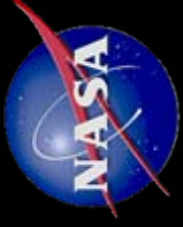
Immunology and Hematology



- Causes
 - Loss of plasma and red blood cells
 - Stress
 - Altered environmental, radiation, and chemical exposures
- Consequences
 - Decrease in red cell mass
 - Increase in white blood cell counts
 - Changes in the ability of lymphocytes to react to foreign materials
 - Number of lymphocytes decreased and neutrophils increased



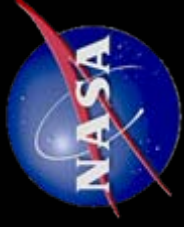
Immunology and Hematology



Countermeasures

- Shielding (structural, chemical) for radiation
- Stress reduction
- Nutritional, pharmacologic, and immunologic prevention and treatment
- Microbiocidal prevention of opportunistic infection





Environment

- Causes
 - Acoustics
 - Microbiology
 - Radiation
 - Toxicology
 - Water quality





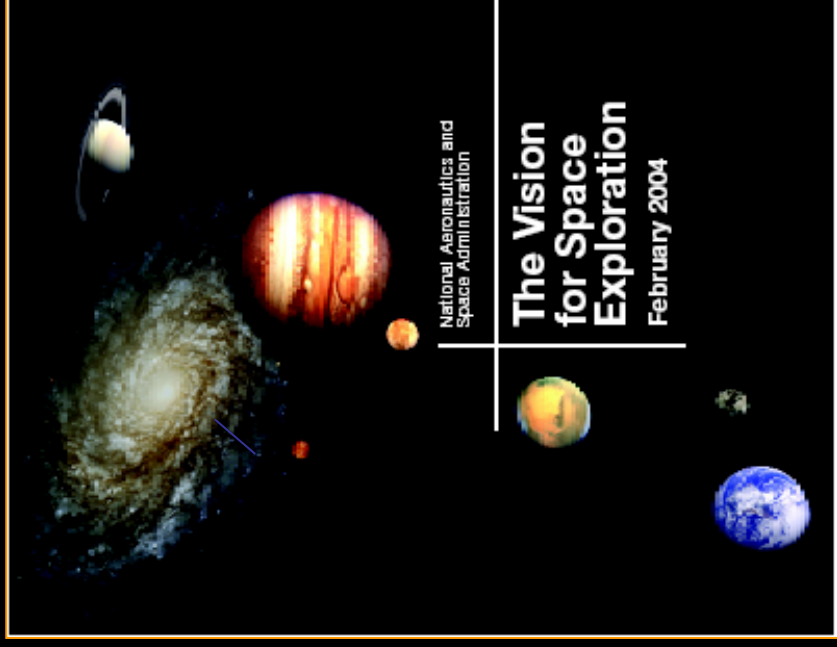
Environment

Countermeasures

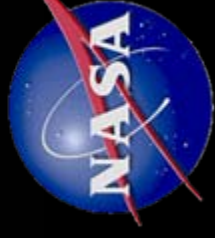
- Monitoring
- Recycling water
- Waste management
- Air scrubbers
- Thermal control systems
- Radiation shielding



The Vision for Space Exploration



Exploration



4-6 crew to lunar surface
for extended-duration stay

Long duration human
lunar exploration

2020 - TBD

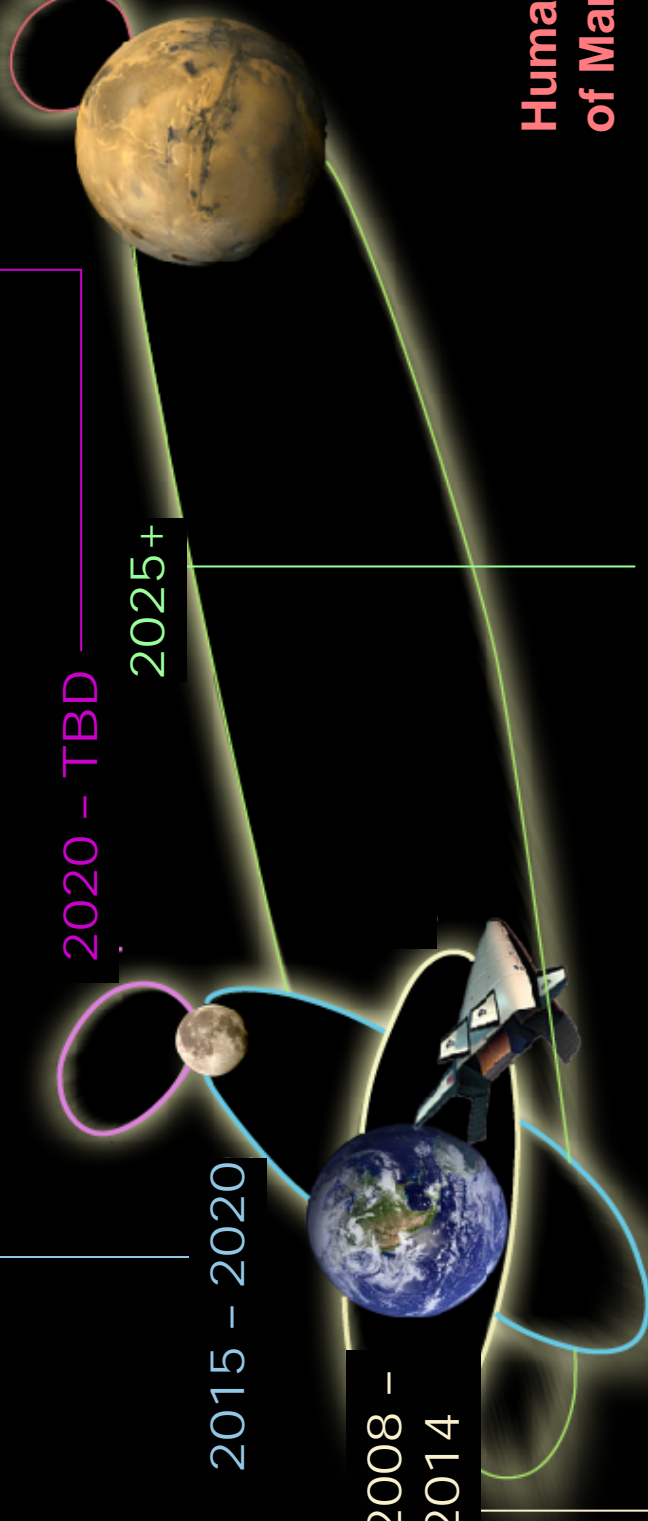
2025+

2030+

Human exploration
of Mars surface

Human exploration
to Mars vicinity

Transportation System to
Low Earth Orbit



Building Block Approach



Humans on
the Moon



Humans to
Mars



Complete
ISS



Exploration Issues

- Communication delays (up to 40 minutes to Mars) and/or long periods without communication
- Limited or no ability to return to Earth for contingencies
- Autonomous clinical care
- Psychosocial, behavior and performance issues
- Improved therapeutics
- Increased diagnostic capabilities
- Integrated micro-g and low-g diagnostic/treatment protocols
- Medical consumables

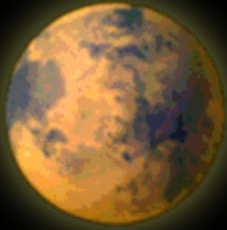
Life Sciences' Contributions

Health Care

Habitability

Environments





Health Care

- Medical requirements and standards
- Evidence-based medical care
- On-orbit clinical capabilities
- Medical selection and retention
- Crew certification
- Countermeasures
 - Physiological changes
 - Behavioral sciences





Habitability

- Human physical parameters
- Performance capabilities and limitations
- Crew station integration
- Crew interface analysis
- Habitat design
- Human-machine interfaces
- Space human factors
- Food systems





Environments



- External
 - Temperature extremes
 - Vacuum
 - Increased radiation levels (solar, cosmic)
- Internal (spacecraft)
 - Atmospheric composition and purity
 - Air, food, water, and noise
 - Spacecraft configuration
 - Microbiological concentrations & alterations



Questions?

